COASTAL SAGE SCRUB SERIES OF WESTERN RIVERSIDE COUNTY, CALIFORNIA

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Abstract

The widely used term "Riversidian sage scrub" distinguishes coastal sage scrub in interior cismontane southern California from stands elsewhere but does not account for the considerable variation among stands within the region. Coastal sage scrub classification has generally emphasized either regional or floristic variation. We collected data at 181 coastal sage scrub sites in western Riverside County and classified them using multivariate cluster analyses of structural and floristic variables of shrub canopies. Roughly half of the sites fell into seven coastal sage scrub "series," largely comparable to the six interior basin "associations" described by Kirkpatrick and Hutchinson (1977). Our analysis splits Kirkpatrick and Hutchinson's *Artemisia californica-Eriogonum fasciculatum-Salvia apiana* association into three series; we did not sample their *Lepidospartum squamatum–Eriodictyon crassifolium–Yucca whipplei* association; and we recognize a deerweed series not sampled in their work. Similarities to the earlier analysis indicate that classification of this vegetation is largely repeatable, while discrepancies result from differing methodology and interpretation. The large proportion of unclassified plots suggests that these series represent segments of continua rather than discrete communities. We encourage land use planners to recognize variation among coastal sage scrub series within geographic regions to assure adequate conservation planning.

Introduction

No two stands of vegetation are identical, and classification is often ambiguous because types may grade into one another along continua. Colinvaux (1993:406–412) rejects vegetation classification and the notion of the plant community. Yet community-level management may be "the only viable strategy for long-term conservation" (Frankel et al. 1995:193). Classification is a necessary premise in conservation planning for ecological units (e.g., communities, ecosystems, or habitats), providing the vocabulary for any discus-

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sion of vegetation. Conservation efforts (DeSimone and Silver 1995) necessitate a classification of coastal sage scrub.

"Coastal sage scrub" is a broad term encompassing a wider variety of floristic composition, structure, and habitat suitability for particular plants and animals than the name implies. Based on 120 sample sites, Kirkpatrick and Hutchinson (1977) identified 11 coastal sage scrub "associations", listing characteristic taxa and describing the physical structure of each one. In addition, they analyzed differences in species composition between two regions (an inland basin and a more coastal area) and concluded that

> In fact, the Diegan and Venturan sage appear to intergrade much more gradually than the coastal and inland basin sage distinguished in this study. Thus, at a gross classification level there can be cause for recognizing Venturan, Diegan and Riversidian coastal sage scrub.

Since then, coastal sage scrub classifications have tended to emphasize either (1) Kirkpatrick and Hutchinson's (1977) regional categories, or (2) their floristic assemblages.

Axelrod (1978) retained the name "Riversidian sage scrub" for the interior region and coarsely mapped its distribution. Westman (1983) modified Axelrod's map based on 99 plot sites from the San Francisco Bay area through northern Baja California. Holland (1986) combined Westman's nomenclature with Cheatham and Haller's (1975) geographic subdivisions, but used the spelling 'Riversidean' for the inland basin region. The California Department of Fish and Game's Natural Diversity Data Base (1990) adopted Holland's nomenclature, retaining the original spelling of Riversidian.

Paysen and coworkers (1980) emphasized floristic rather than geographic variation. They recognized eight "series" within their "soft chaparral subformation"; five or six of their series are encompassed within typical descriptions of coastal sage scrub (e.g., Munz 1959), but do not account for the diversity of Kirkpatrick and Hutchinson's (1977) 11 associations. DeSimone and Burk (1992) analyzed 54 plot sites within a small portion of Westman's (1983) Diegan region and identified five "subassociations". Some of these resemble vegetation considered more typical of other geographic areas, indicating that the geographic nomenclature does not adequately represent local variation in coastal sage scrub. Davis and coworkers (1994) identified 13 "species assemblages" based on dominant plants in large (1 km^2) mapping units. Sawyer and Keeler-Wolf (1995) recognized 15 coastal sage scrub "series", based on these and other quantitative and qualitative descriptions. The terms "association" (as used by Kirkpatrick and Hutchinson 1977), "subas-

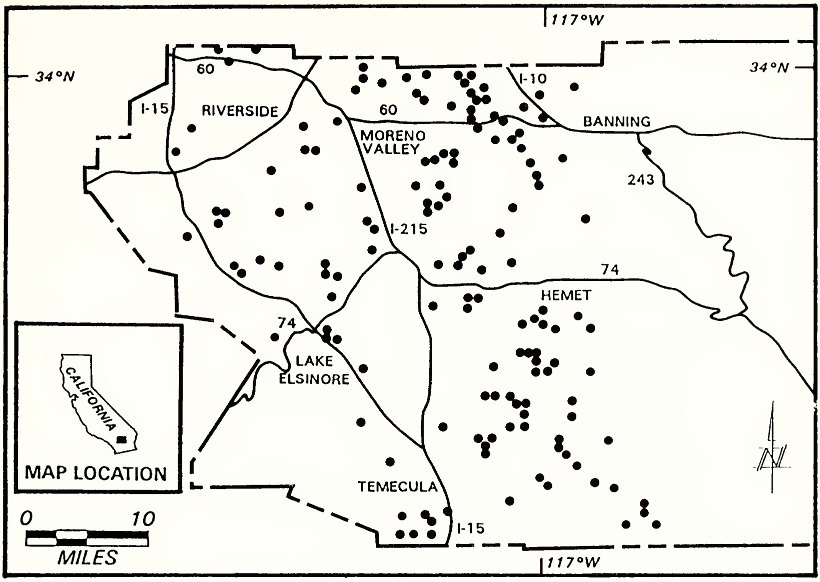

FIG. 1. Study area and sample sites.

sociation" (DeSimone and Burk 1992), and "series" (Paysen et al. 1980; Sawyer and Keeler-Wolf 1995) are roughly equivalent.

DeSimone and Burk (1992) emphasized that more detailed information on variation within geographic regions was needed for conservation planning and Read (1994) stressed the importance of local and regional variation to ecological restoration. In this report, we analyze 181 new plots in western Riverside County and compare them to six assemblages Kirkpatrick and Hutchinson (1977) described in the interior basin. This classification is one component of baseline data intended for use in a regional multiple-species habitat conservation plan (Pacific Southwest Biological Services 1995).

METHODS

Vegetation data were collected at 181 sites within a study area defined by the Riverside County Habitat Consortium (Fig. 1) entirely within Kirkpatrick and Hutchinson's interior basin and Westman's "Riversidian" region). The 540,000 ha study area encompasses about 68,000 ha of coastal sage scrub. It was stratified into 68 whole or partial townships as shown on USGS maps. Total acreage of coastal sage scrub within each township was estimated from aerial photographs (Pacific Southwest Biological Services 1995). Within each township, each ¼ section (ca. 65 ha; 160 acres) was numbered. Quarter sections supporting coastal sage scrub in patches

≥2 ha were selected randomly to total 12% of the coastal sage scrub within each township. Written permission was requested from the owner(s) of each selected ¼ section to survey for biological resources. Permission was granted to sample sites totaling 2700 ha (4%) of mapped coastal sage scrub within the study area. Vegetation data were collected at one to four sites within each ¼ section, depending on the extent and distribution of coastal sage scrub. Each selected ¼ section was stratified into 16 ha (40 acre) 1/16 sections and one site was sampled within each 1/16 section where coastal sage scrub occurred. In addition to collecting vegetation data, each site was surveyed for presence of California gnatcatchers (*Polioptila californica*) (Padley in preparation).

Sample sites were centered near the center of coastal sage scrub patchs as identified on aerial photographs prior to visiting the site, except where California gnatcatchers were detected. On these sites, center points were moved to the initial California gnatcatcher position. Location (Township, Range, and 1/16 section), elevation, slope, and aspect were recorded at each site's center point. Sampling methodology was modified from Evans and Love (1957). Fifty toe-point intercepts were recorded at 2-step (roughly 2 m) intervals along two 100-step transects. Transects originated at the center point, and were directed at 360° and 90° azimuths (north and east, respectively). Shrub cover (species and height) and ground layer (recorded as soil, rock, road, litter, or herbaceous plant category) intercepting a line projected vertically from each toe-point were recorded. If no plant intercepted the vertical line, then no species was recorded. Herbaceous plants were categorized as native or non-native and as forb or grass, but herb species names were not recorded.

Data were analyzed using cluster analysis of cases (an agglomerative program which generates a dendrogram), K-means clustering of cases (a non-hierarchial divisive program), and stepwise discriminant analysis (BMDP Statistical Software 1994). Data were arranged into groups with both cluster programs, using frequency for taxa and herb categories occurring at ≥1.0% average frequency throughout the entire data set. These variables were non-native herbs, native herbs, non-native grasses, *Salvia mellifera*, *Encelia farinosa*, *Eriogonum fasciculatum*, *Artemisia californica*, *Adenostoma fasciculatum*, *Lotus scoparius*, *Salvia apiana* frequencies. In cluster analysis of cases, the sum of squares algorithm was used with the centroid clustering method. K-means clustering of cases used unit variance standardized data, set to identify 15 clusters (after preliminary analyses with other values). Results of the two cluster analyses were compared and plots were assigned to groups when both analyses placed them into similar clusters. Plots not clustered similarly by the two programs (68) were excluded from further analysis. Three clusters (totaling 24 plots) were dominated by non-native

TABLE 1. COASTAL SAGE SCRUB SERIES IN WESTERN RIVERSIDE COUNTY, CALIFORNIA.

Series	California sagebrush	California buckwheat	CA sagebrush-CA buckwheat	CA sagebrush-white sage	Brittlebush	Black sage	Deerweed
No. of plots	7	8	33	5	14	17	5
Mean elev. (m)	410	550	490	380	610	640	580
Mean cover of selected species and categories (%)							
Shrubs	72	51	45	57	51	71	48
Non-native grasses	3	10	12	2	6	11	16
Non-native herbs	7	6	23	11	16	15	10
Native herbs	9	14	5	14	4	1	6
Salvia mellifera	3	0	0	2	2	32	14
Encelia farinosa	0	0	3	0	41	8	4
Eriogonum fasciculatum	11	45	19	2	2	6	7
Artemisia californica	42	0	16	21	5	15	2
Lotus scoparius	2	3	1	0	0	0	14
Salvia apiana	11	0	1	27	0	0	0
Mean height of selected species (m)							
Salvia mellifera	0.3	—	—	0.3	0.2	1.1	1.0
Eriogonum fasciculatum	0.6	0.7	0.6	0.5	0.1	0.6	0.6
Artemisia californica	0.7	—	0.8	0.8	0.4	0.8	0.5

herbs or grasses with little native shrub frequency. Reviewing the original data revealed that transects at these sites were only partially within coastal sage scrub, crossing into annual grassland over the remainder of their lengths. They were excluded from further analysis. Plot groups characterized by native shrubs were named as series using Sawyer and Keeler-Wolf's (1995) nomenclature or by novel names following Sawyer and Keeler-Wolf's style (i.e., by common names of dominant species).

Series were compared using stepwise discriminant analysis to identify the most useful variables for distinguishing between them, using all available variables. The program was run twice with all series, first using vegetation data (species frequency and height), and then using location (township and range), elevation, slope, and cosine-transformed aspect variables (so that slopes with similar exposure would have similar values).

RESULTS

Seven coastal sage scrub series were identified (Table 1 and Fig. 2). Two series (California sagebrush and California sagebrush-white sage) were classified ambiguously by the two cluster programs but were retained in the classification (identical sets of plots were placed

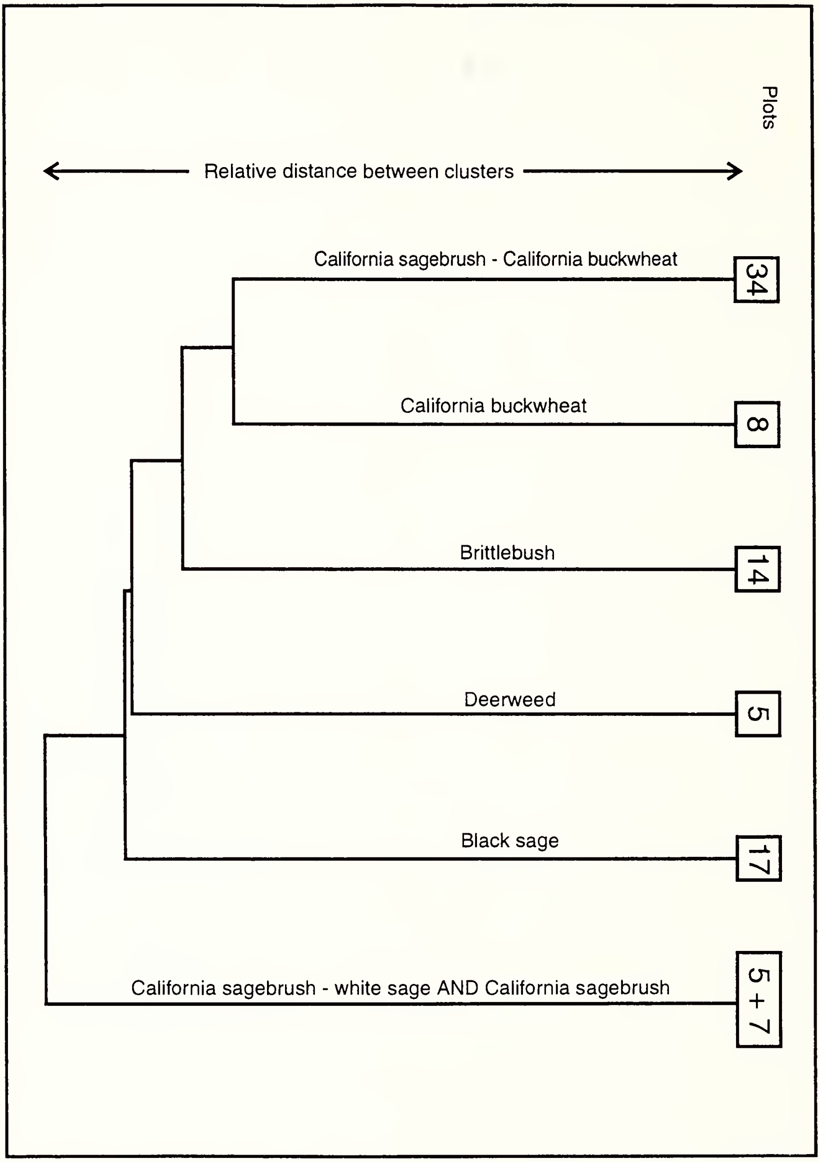

FIG. 2. Results of cluster analyses. Dendrogram indicates results of cluster analysis of cases (vertical scale is proportional to cluster similarity); numerals indicate number of plots shared with K-means cluster analysis results.

into two clusters by K-means clustering of cases, while stepwise clustering of cases combined them).

We classified plots conservatively, assigning them to categories only when both programs clustered them similarly (except as noted above). Eighty nine plots were classified into seven coastal sage scrub series. Twenty four were classified as partially covered by annual grassland and were discarded from the classification. The remaining 68 plots were discarded from the classification due to inconsistent classification or placement into "catch-all" groups.

Stepwise discriminant analysis used 11 vegetation variables to discriminate among the series with 96% overall success. In order of importance, the variables were: *Salvia mellifera* frequency, *Encelia farinosa* frequency, *Salvia apiana* frequency, *Lotus scoparius* frequency, non-native grass frequency, total shrub frequency, *Artemisia californica* frequency, *A. californica* height, *Eriophyllum confertiflorum* frequency, *Eriogonum fasciculatum* height, and non-native herb frequency. Stepwise discriminant analysis had generally poor success discriminating between vegetation series using geographic and physical variables. Township, range, and elevation were the three most useful of these, and were used to classify the black sage and brittlebush series with about 50% success. Other series were classified with much lower success rates.

Kirkpatrick and Hutchinson (1977) named "associations" using scientific names of characteristic species, but Sawyer and Keeler-Wolf (1995) used common names in their nomenclature. We follow Sawyer and Keeler-Wolf's nomenclature and style and provide corresponding scientific names to minimize difficulty in comparing these series to Kirkpatrick and Hutchinson's categories.

The Brittlebush (*Encelia farinosa*) series recognized here matches Sawyer and Keeler-Wolf's Brittlebush series and corresponds well to Kirkpatrick and Hutchinson's *Encelia farinosa–Mirabilis laevis* (brittlebush-California wishbone bush) association, though *M. laevis* occurs at low frequency in our data. Our data match Kirkpatrick and Hutchinson's description of physiognomy: this vegetation is open (rarely more than 60% shrub frequency), with lower stature than most other series.

Our Black sage (*Salvia mellifera*) series and California sagebrush (*Artemisia californica*) series correspond respectively to Sawyer and Keeler-Wolf's series of the same name and to Kirkpatrick and Hutchinson's *Salvia mellifera–Eriogonum fasciculatum–Bromus rubens*, and *Artemisia californica* associations, respectively. Both series are characterized by higher mean total shrub frequency (> 70%) than other series we identify here.

Our analysis splits Kirkpatrick and Hutchinson's *Artemisia californica–Eriogonum fasciculatum–Salvia apiana* (California sagebrush–California buckwheat–white sage) association into three series: California buckwheat, California sagebrush–California buckwheat, and California sagebrush–white sage series. They all match Kirkpatrick and Hutchinson's description of open physiognomy dominated by a low shrub layer and with high herb cover. In recognizing California buckwheat and California sagebrush–California buckwheat as separate series, we follow Sawyer and Keeler-Wolf (1995). The California sagebrush-California buckwheat series is the most common and widespread series in our data, occurring almost throughout the geographic range of coastal sage scrub in Riverside County.

Our California sagebrush–white sage series is encompassed by Sawyer and Keeler-Wolf's white sage series. It was combined with the California sagebrush series by one program in our analysis. We chose to recognize it as a separate series because high *Artemisia californica* frequency distinguishes it from Kirkpatrick and Hutchinson's *Artemisia california–Eriogonum fasciculatum–Salvia apiana* association, while structure and floristic differences separate it from the California sagebrush series in the K-means cluster analysis. We use the name California sagebrush–white sage series, rather than Sawyer and Keeler-Wolf's White sage series, because average *Artemisia californica* frequency is nearly as high as *Salvia apiana*. We acknowledge that these plots are intermediate between other series and might validly be included within one of the others (i.e., an "association" in Sawyer and Keeler-Wolf's usage).

We identified a deerweed (*Lotus scoparius*) series not described by Kirkpatrick and Hutchinson (1977) or Sawyer and Keeler-Wolf (1995). Most of these plots are in areas where wildfire had occurred a few years previous to sampling. *Lotus scoparius* is often most common in early post-fire stands (Westman 1981; Keeley and Keeley 1984) and we suspect that these plots are transitional to other coastal sage scrub or chaparral series. Kirkpatrick and Hutchinson (1977) did not sample burned sites, so presumably excluded *Lotus scoparius* dominated sites from their data.

Discussion

Two of Kirpatrick and Hutchinson's (1977) associations were not identified in this analysis. Their *Eriogonum fasciculatum–Scrophularia californica–Phacelia ramosissima* (California buckwheat–California figwort–perennial phacelia) association could not have been identified by our analysis because native herb species were not recorded during data collection. Kirkpatrick and Hutchinson characterized this association by an abundance of granitic boulders. We noted that high boulder cover was characteristic of plots in the northeastern study area, and these probably correspond to Kirkpatrick and Hutchinson's *Eriogonum fasciculatum–Scrophularia californica–*

Phacelia ramosissima association. These plots generally fell into our California buckwheat series. Kirkpatrick and Hutchinson's *Lepidospartum squamatum–Eriodictyon crassifolium–Yucca whipplei* (scalebroom–yerba santa–chaparral yucca) association occurs on infrequently flooded alluvial fans and washes (Smith 1980). It was described as Scalebroom series by Sawyer and Keeler-Wolf (1995). Within Kirkpatrick and Hutchinson's (1977) interior basin, most of its extent is in southwestern San Bernardino County, north of our study area.

This analysis largely confirms Kirkpatrick and Hutchinson's (1977) descriptions of coastal sage scrub variation in the inland basin. Principle differences between the two analyses result from differences in sampling technique: they subjectively selected sites to represent all environmental conditions and species assemblages whereas our random selection method may have missed uncommon assemblages. Also, they recorded all species occurring in an indeterminate-sized plot whereas we combined herbaceous species into a few categories and recorded only species occurring at toe-points along structured transects. Similarities to Kirkpartrick and Hutchinson's (1977) results indicate that coastal sage scrub classification is largely repeatable by independent analyses, though differing methodology and interpretation affect the results.

We share DeSimone and Burk's (1992) view that more detailed understanding of local variation within coastal sage scrub is needed for management and conservation planning, and we encourage planning and resource agencies to continue examining this variation. We particularly note that our classification does not consider herbaceous species which account in large part for variation in species richness among coastal sage scrub stands (Westman 1981).

Planners and land managers should not assume that all coastal sage scrub stands will provide suitable habitat for plants and animals whose habitat is described as simply "coastal sage scrub". Floristic and physiognomic differences among coastal sage scrub series offer differing habitat resources to plants and animals. Floristic differences may reflect differing climatic or edaphic conditions, may affect habitat suitability for taxa of special concern, and may support differing assemblages of specialist animal species. Similarly, structural differences will affect understory light availability, cover availability, or animals' ability to detect prey. We recommend conservation planning to encompass as wide a range of conditions as possible, though we recommend against conservation planning for the Deerweed series due to its evident transitional nature.

The series described here successfully classify much of the variation among shrub canopy composition in Riverside County's coastal sage scrub, though gradation among these series and among coastal sage scrub, chaparral, and annual grassland is evident. The large proportion of unclassified plots is evidence that series recognized here intergrade into one another along continua in structure and/or floristic composition. Many of the unclassified plots seem to be intermediate between series described here or between coastal sage scrub and chaparral (e.g., several unclassified plots include *Adenostoma fasciculatum* or *Ceanothus crassifolius*).

There is wide variation between adjacent coastal sage scrub stands in Orange County (DeSimone and Burk 1992), and similar variation can be seen in Riverside County. If a conservation plan represents series described here in areas large enough to effectively manage edge effects, fire ecology, and California gnatcatcher populations, then we expect that additional canopy diversity represented by our unclassified plots will also be included.

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